CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-19

March 1, 1977

1. Name of fault: San Cayetano fault.

2. Location of fault: Ojai, Santa Paula Peak, Fillmore and Piru quadrangles, Ventura County (see index map).

3. Reason for evaluation: Part of 10-year program; zoned in the Ventura County Seismic and Safety Element.

4. List of references:

a) Bertholf, H.W., 1967, Geology and oil resources of the Timber Canyon area, Ventura County, California: Unpublished M.S. thesis, University of California, Los Angeles, 56 p., 10 plates, geologic map scale 1:12,000.

b) Bush, G.L., 1956, Geology of Upper Ojai Valley: Unpublished M.A. thesis, University of California, Los Angeles, 60 p., 10 plates, geologic map scale 1:12,000.

c) Dibblee, T.W., Jr., 1939, Unpublished geologic map of the Santa Paula quadrangle, scale 1:62,500.

d) Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1, scale 1:750,000.

e) Jennings, C.W., and Strand, R.G., 1969, Geologic map of California, Los Angeles sheet: California Division of Mines and Geology, scale 1:250,000.

f) Kew, W.S.W., 1924, Geology and oil resources of a part of Los Angeles and Ventura Counties, California, U.S. Geological Survey Bulletin 753, 202 p., 2 plates, map scale 1:62,500.

g) McCullough, T.M., 1957, The geology of the Timber Canyon area, Santa Paula Peak quadrangle, Ventura County, California: unpublished M.A. thesis, University of California, Los Angeles, 67 p., 6 plates, geologic map scale 1:18,000.

h) Nichols, D.R., October 1974, Surface faulting in Seismic and Safety Elements of the Resources Plan and Program: Ventura County Planning Department, section II, p. 1-35, plate 1.

i) Putnam, W.C., May 1942, Geomorphology of the Ventura region, California: GSA Bulletin, v. 53, p. 691-754, 5 plates, 11 figures.

j) Schlueter, J.C., 1976, Geology of the Upper Ojai-Timber Canyon area, Ventura County, California: Unpublished M.S. theiss, Ohio University, 76 p., geologic map scale 1:12,000.

k) Weber, H.F., Jr., Cleveland, G.B., Kahle, J.E., Kiessling, E.F., Miller, R.V., Mills, M.F., Morton, D.M., and Cilweck, B.A., 1973, Geology and mineral resources study of southern Ventura County, California: California Division of Mines and Geology, Preliminary Report 14, 102 p., map scale 1:48,000.

l) Weber, F.H., Jr., Kiessling, E.W., Sprotte, E.C., Johnson, J.A., Sherburne, R.W., and Cleveland, G.B., 1975, Seismic hazards study of Ventura County, California: California Division of Mines and Geology, open file report,76-5LA, 396 p., 9 plates.

m) Yeats, R.S., Schlueter, J.C., Butler, M.L., and Çemen, Ibrahim, 1976, Santa Susana-San Cayetano-Red Mountain fault system: Unpublished summary report for U.S. Geological Survey, contract no. 14-08-0001-15886.

n) Ziony, J.E., Wentworth, C.M., Buchanan-Banks, J.M., and Wagner, H.C., 1974, Preliminary map showing recency of faulting in coastal southern California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-585, 15 p., map scale 1:250,000, 3 plates.

5. <u>Summary of available data:</u>

The San Cayetano fault is zoned as a primary fault hazard ("zones which contain faults which have been active during historic or Holocene time) in the Ventura County Seismic and Safety Element (Nichols, 1974, after Weber, et al., 1973).

Weber, et al. (1973) states "The ... San Cayetano fault zone [as a whole] should be considered active." They note that physiographic features are present along the San Cayetano which "suggest Holocene displacement."

Weber, et al. (1975, p. 172) describe the fault as a northward dipping (20^{o} to 50^{o}) thrust fault with 30,000 feet of throw. Features suggesting "youthful" faulting include: a "scarp along the north side of Ojai Valley, along which late Quaternary gravels are faulted upward to north at least 200 to 300 feet; abundant oil and tar seeps; modified scarps and linear fault features, apparent faulting of older and possibly younger alluvium in southeast corner of Ojai Valley; and steep south front of Santa Paula Ridge." These features, and others, are shown on plates 1 through 4. Weber, et al (1975) also show the western end of the zone to be a complex zone of fault traces. It is not clear from their map which ~~trace(s)~~ traces are actually branches of the San Cayetano fault ~~(zone)~~ and which are other faults.

Kew (1924, p. 100-101), in describing his San Cayetano-Santa Susana-Sierra Madre fault, stated that the San Cayetano fault "is covered by the alluvium of Santa Clara River and Sespe Creek". He also states that there are three "more or less distinct" fault traces. However, he found fractures "too numerous to show" on his map. He does state that "The (fault) movement occurred...during the Pliocene epoch and has continued to Recent time."

Putnam (1942, p. 705) states the fault disappears under the alluvium in the Ojai Valley, to the west. He notes a 2000-foot high "composite fault-line scarp" along Santa Paula Ridge. Putnam notes:

INDENT AS LARGE QUOTE

"The San Cayetano thrust is probably still active. Terrace gravels north of the fault east of Sisar Creek are tilted 25° north towards their source in the Santa Ynez Mountains. It is possible that the difference in elevation of 250 to 300 feet between the Upper Ojai Valley and the dissected fans on either side of Sisar Creek (see plate 1) is the result of uplift of the fans by the fault. The evidence is largely topographic, but the fans are truncated at the fault, and streams crossing the fans are entrenched in valleys 250 to 300 feet deep."

Schlueter (1976, p. 47) notes that this truncation of fan deposits is the "...strongest line of evidence of late Quaternary and possible Holocene movenent..." along the San Cayetano fault. Schlueter also notes that, although he depicts the fault as cutting older alluvial ~~stream (terrace)~~ deposits in Santa Paula Creek (Sec. 16, T. 4 N., R. 21 W.) he did not actually see this contact -- it was obscured by brush. However, he notes that ~~the~~ that stream deposits ~~terrace~~ appeared to be warped, suggesting that they ~~terrace~~ were ~~was~~ overridden by the fault.

Nichols (1974, p. 11-9) states that the San Cayetano fault is part of the "Red Mountain-San Cayetano-Santa Susana-San Fernando fault system." He feels that this system should be considered active on the basis of the 1971 San Fernando earthquake (and other epicenters), groundwater barriers, and displaced alluvium. Further, he notes that there are "unusually high fluid pressures in the Ventura and San Miguelito oil fields (which are believed to indicate that tectonic stress has accumulated along (that section of) the fault system between the Red Mountain and San Cayetano faults).

Bush (1956) and Bertholf (1967) both state that the San Cayetano fault has been active during the Holocene (Recent). (The traces of Bush's and Bertholf's faults were also shown by Weber, et al., 1973). Bush notes (p. 46) a scarp in the Sisar fan. However, his map shows the fault as concealed by every (Holocene) fan deposit along the fault. Bertholf also shows the fault as not cutting older (Pleistocene) terrace deposits.

McCullough (1957) also shows the fault on his map of the Timber Canyon area, but he notes that he did not actually observe the fault. Dibblee (1939) also mapped parts of the San Cayetano fault (see plates 1 and 2).

Ziony, et al. (1974) appears to connect~~s~~ the San Cayetano with the Santa Ana fault rather than with the Red Mountain fault. They conclude that the San Cayetano fault is late Quaternary in age, based on a fault-related geomorphic feature (not specifically described) north of Upper Ojai Valley, near Sisar Creek. Another such feature is noted northwest of Fillmore, and an offset Pleistocene deposit (probably a terrace) is offset northeast of Fillmore. Their work is based on the mapping of others (referred to in this report) plus unpublished mapping and air photo interpretation.

6. <u>Interpretation of air photos:</u> Three sets of aerial photographs were viewed steroscopically. ERTS photographs flight 73-006 (January 1973), numbers 7601 through 7604 and 7620 through 7622 (scale 1:125,000) revealed no clear indications that fans or other alluvial deposits were faulted.

U.S. Department of Agriculture air photos series AXI (1953) 1K-49 through 51, 2K-79 through 82, 3K-90, 91, 129, 130, 131, 136, and 137, 4K-7, 8, 9, 19, 50, and 51., 8K-28, 29, 58, 59, 90 and 91, and 9K-80, 81, 122, and 123 (scale 1:24,000) revealed numerous features such as scarps, breaks in slope, landslides, etc. (see plates 1, 2, and 3). I question whether some of the scarp features on Santa Paula Ridge (Sec. 13, 14, 15 and 16, T. 4 N., R. 21 W) which face the wrong direction are actually fault scarps or are landslide scarps (including those that may be earthquake induced). However, most of these scarps align with, and are within 1/2 mile of, the mapped traces of the San Cayetano fault. Most of these scarps cross the bedding trend at an angle.

The third set of photos are from the Whittier Collection, Flight C509, scale 1:18,000, flown in 1929 (those photos pre-date the oil field development). Photos F30 and F31 revealed a south-facing scarp in older alluvium must north of Fillmore in sec. 19 (see plate 3). Photos G16 and G17 revealed that the north facing scarp in bedrock just north of Camp Bartlett probably is a natural feature that has since been modified (plate 2). H24 and H25 show what appears to be a north-facing scarp in a fan (Sec. 15, T. 4 N., R. 20 W.) approximately where Ziony, et al., (1974) note evidence of late Quaternary movement (see plate 3).

Flight C9460 (from the Whittier Collection), photos 16 through 19 were missing from the Whittier Collection. These photos cover the San Cayetano fault just north of Piru (site discussed in Item 7).

Flight C45 (also from the Whittier Collection), scale 1:12,000, flown 1927, numbers D29 and D30, which cover the Real Canyon site (see Item 7) were also viewed (see plate 4). No features indicative of recent surface fault rupture were noted.

7. Field observations:

A reconnaissance was made of the accessable western and eastern ends of the San Cayetano fault. Specific areas that were not visited, but that inspections might be desirable include Timber Canyon fan and the south flank of Santa Paula Ridge. I attempted to reach the site of the scarp noted (in photos C509, H24-H25) above. However, I was unable to gain access due to the steep terrain and dense brush. This may be the feature noted by Ziony, et al. (1974), as evidence for late Quaternary movement.

Two sites were studied in some detail. The first was the area just north of Camp Bartlett. Approximately one full day was spent in this area, examining the San Cayetano fault. The north-facing scarp, noted above in Item 6 and on plate 1, is still apparent, although it has been modified by grading and presently is the site of several oil wells and tank facilities. The scarps parallel the strike of the bedding present in the southern block, which dips about 20^{o} north. North of this escarpment the rock is highly sheared in places. Exotic slices of Sespe Formation (see photo 2) and other units are present in the zone.

Many of these slices are quite coherent. In other slices, the material is very broken and "punky" rock that tends to slide. Oil seeps are present throughout the zone. Photos 1a through 1d depict a single fault plane in the zone. The colluvium noted in photos 1a and 1b has been affected by the fault, but I could not trace any fault plane through the colluvium. It is possible that some of the fault breccia noted may be older colluvium. It is also possible that the colluvium below the projected fault plane was overthrust by bedrock and that the bedrock above the fault either has since disintigrated, or was covered by colluvium.

In the Camp Bartlett area it was quite evident that the San Cayetano fault is actually a wide zone of faults, not all of which are noted on the map. Most of these faults appear to lie between the San Cayetano fault and Sisar fault, as shown by Weber, et al.,(1975). However, I was able to find another fault to the north in NW 1/4, sec. 16, T. 4 N., R. 21 W. (plate 2) which I feel is also a trace of the San Cayetano. No evidence of faulting was noted in Holocene alluvium of the Santa Paula Creek to the east.

The second site examined was just northwest of Piru, at a scarp in a stream terrace which Weber, et al. (1975) concluded to be the result of late Quaternary (?) faulting. After some digging with a shovel to remove colluvial and landslide debris covering the terrace deposit, I concluded that the scarp was not due to faulting. Perhaps it was man-modified (the site from which road base material was taken?), or perhaps it is an old meander scar of Piru Creek. In any case, the bedding in the stream terrace was not warped, but dipped gently to the south. While I did not remove the entire landslide deposit, I was able to remove enough that I could match the cobble and sand beds on either side, and could determine that, if the fault did exist in the deposits, the amount of vertical displacement was less than about 3 inches. One could not, therefore, explain the presence of a 5-foot high scarp as purely due to fault movement (see sketch and photos 4a, b, c, 5, 6, and 7). An additional scarp was noted east of Piru Creek, but no faults were noted in the bedrock east of the creek that could explain such a scarp. The trend of the scarp was such that it could easily be explained as a former stream bank.

A third site that I visited was the mouth of Sisar Canyon (plate 1) on October 5, 1976. I noted a prominent scarp (see photo 9) about 80+ feet high, sloping about 30° southward. The scarp was in a fanglomerate deposit (late Pleistocene?). South of the scarp, alluvium was present. I could not observe whether or not the alluvium was faulted against the fanglomerate.

Two additional sites were visited. These are noted on plate 3 with the observations made at these sites.

8. Conclusions: Individual, discrete faults can be found within the San Cayetano fault zone that individually may be considered to be well-defined. However, the zone is quite complex and not all the fault traces are shown on geologic maps. In reality, the area between the northernmost and southernmost mapped traces may be highly sheared. Ziony, et al. (1974) show at least one trace, between Fillmore and Piru, which has not been mapped in detail (at a suitable scale) by

any [other] author. Weber, et al. (1975) depict the fault as buried under alluvium in this area, thus most of the fault east of Fillmore appears to be ill-defined.

In some places, the most recently active trace of the fault may be assumed to lie at the principal break in slope. For example, the principal fault trace is fairly well-defined between Santa Paula Creek and 1.5 miles west of Sespe Creek. As one can see from the topographic map, a major break in slope exists along this segment. However, this break (a composite or fault-line scarp) is not the product of a single event, and does not necessarily define the trace of the most recent event along its entire length. It does indicate that most of the displacement has occurred along a single trace, however.

West of Santa Paula Creek, a complex zone of faults exists. Even so, the principal break can be defined by topographic features, such as the scarp at the foot of the Sisar Canyon fan, and other scarps in the Silverthread oil field (sec. 17, T. 4 N., R. 21 W., plate 2).

Parts of two additional faults may be considered as a part of the San Cayetano fault zone. One is the relatively short Vogel fault of Schlueter (1976), which is well-defined as a scarp in undifferentiated alluvial deposits. The second is the Sisar fault east of Camp Bartlett (see Smith, 1977b). However, the topographic evidence for activity of the Sisar fault is not as impressive as that present along the San Cayetano in the same area.

Finally, we turn to the question of activity. Is the San Cayetano fault active? For the purposes of the Alquist-Priolo Special Studies Zones Act, an active fault is defined as a fault that has had movement along it during Holocene time. There is no conclusive evidence of Holocene fault activity along any branch of the San Cayetano fault. All scarps and topographic evidence are in late Quaternary deposits or in bedrock, thus, the age of the most recent surface faulting can only be assigned an age of late Quaternary. However, while Holocene activity has not been proven, that the fault may be active is suggested by the impressive fault-line or composite scarps. It is interesting to note that the San Cayetano fault between Sespe Creek and Wilsie Creek is a much more impressive feature than the faults that ruptured during the 1971 San Fernando earthquake.

9. Recommendations: Based on the data summarized in this report, and on the criteria presently utilized by the California Division of Mines and Geology relating to the Alquist-Priolo Special Studies Zones Act, zoning of the San Cayetano fault is not recommended at this time. While Holocene activity has been suggested, it has not been proven. However, even if the fault has not moved during the Holocene, or even if it has, it may still be the site of a future surface rupture.

10. Investigating geologist's name; date:

Theodore C. Smith

Theodore C. Smith
Assistant Geologist
March 1, 1977

I agree with recommendation. However, when new data becomes available (e.g. Yeats and [illegible] trenching), we should re-evaluate this fault.
EWH
3/15/77

South North

Colluvium

fault plane

breccia

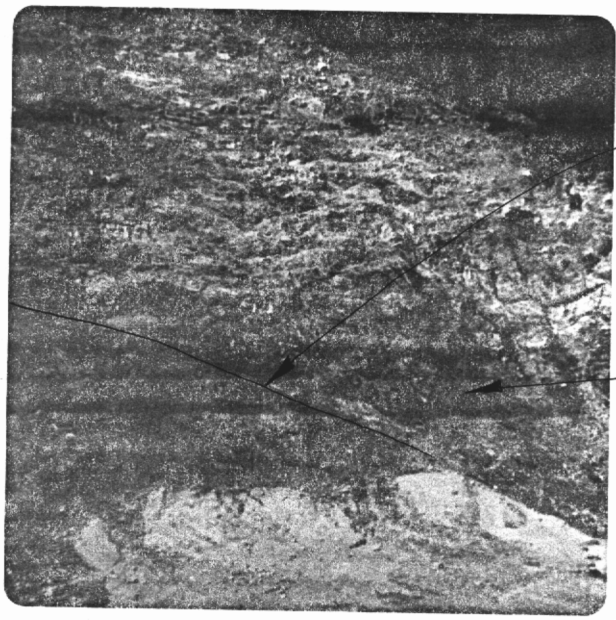
tar Sand

Photo 1a. San Cayetano fault north of Camp Bartlett looking west. Overlaps with photo 16. Bedrock units are unidentified sandstones and shales (pre-Quaternary).

S N.

Photo 1b. San Cayetano fault north of Camp Bartlett. Overlaps with photos 1a and 1c. Note tar along fault.

S N



fault

Tar Sand

Photo 1c. San Cayetano fault north of Camp Bartlett. Overlaps with photos 1b and 1d.

S NW E

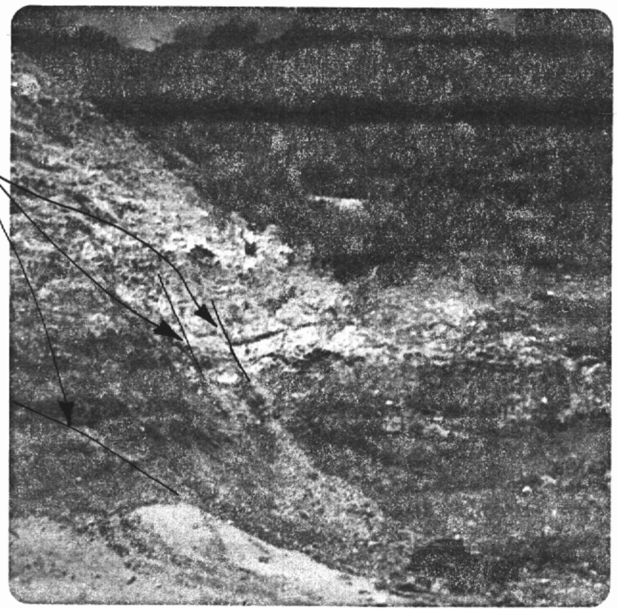


Photo 1d. San Cayetano fault north of Camp Bartlett. Overlaps with photo 1c. Note that the cut face changes direction in right-center of photo (noted so as to avoid confusion).

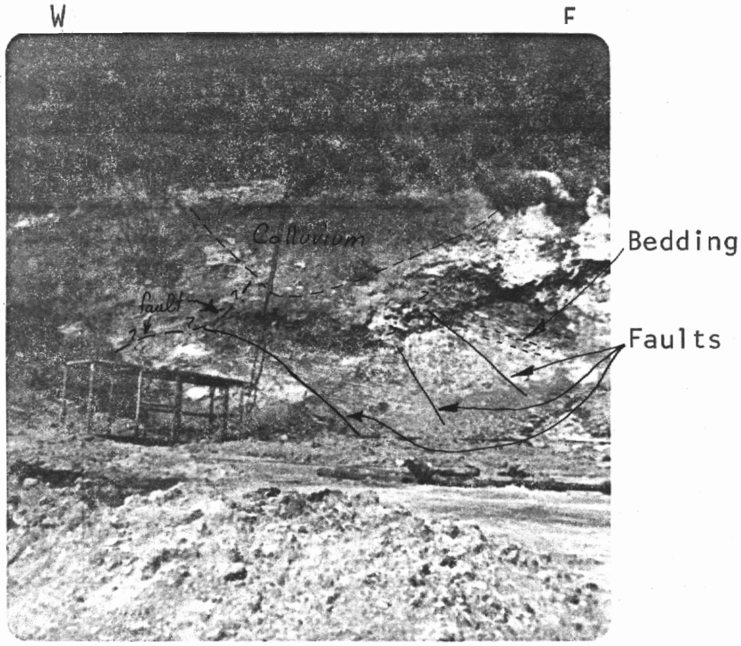


Photo 2. San Cayetano fault north of Camp Bartlett, looking north. Note the shearing and folding of this older bedrock. Red unit on the left is Sespe Formation(?). Other units are jnidentified Miocene(?) sands and shales.

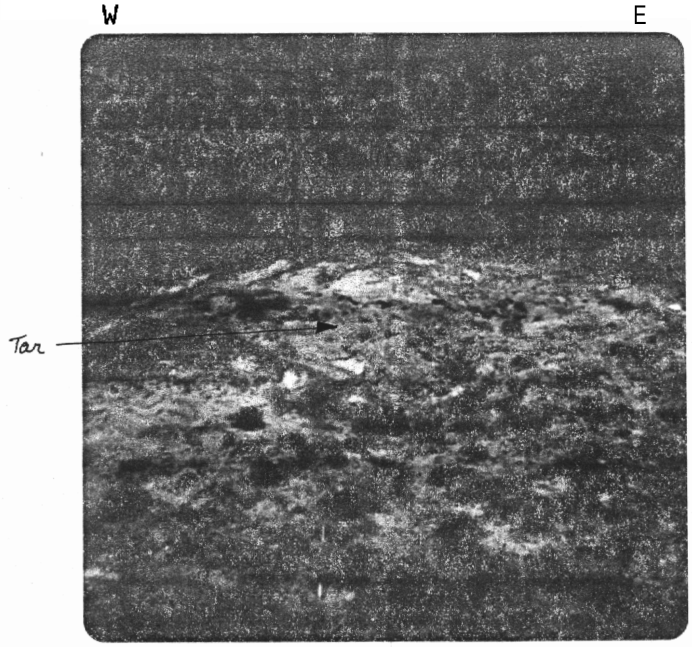
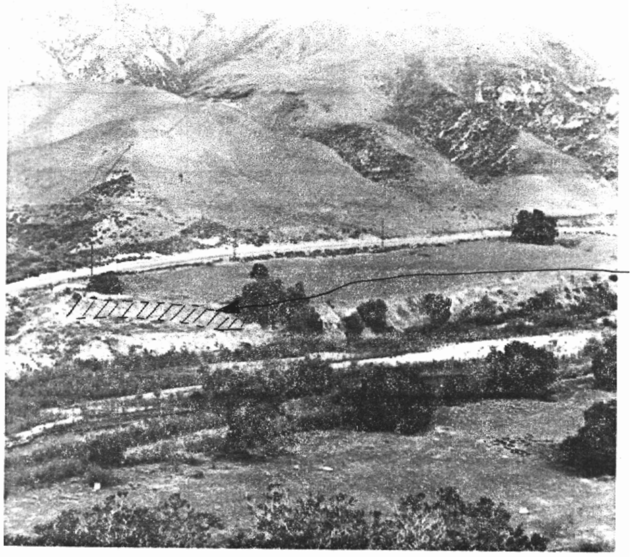


Photo 3. Tar deposits at mouth of Pole Canyon. Several geologists map the San Cayetano fault by such deposits (Dick Berger, 1976, personal communication). This deposit was cited as evidence of the San Cayetano fault in Pole Canyon by an unidentified U.S. Army Corps of Engineers geologist (1976).

S N



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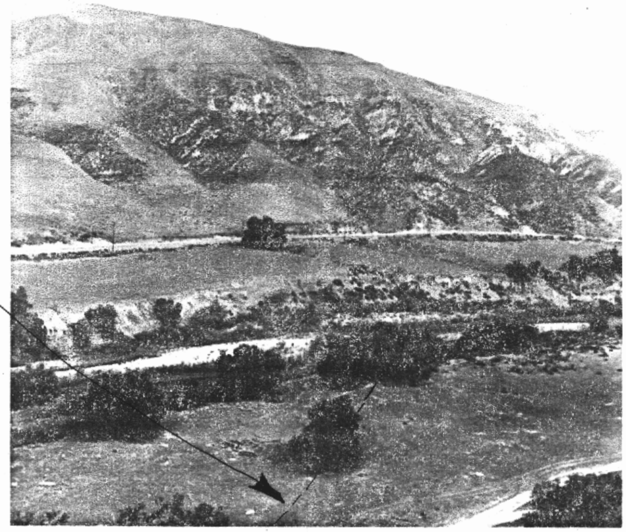
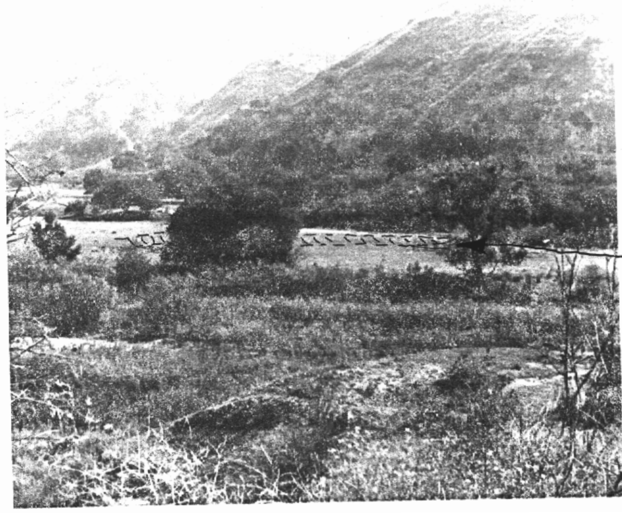


Scarp

Photo 4a. Scarp at Piru Creek. Overlaps with photo 4b. (These scarps were determined to be due to other than active faulting.)

Photo 4b. Scarps of Piru Creek. Overlaps with photo 4a.

N S



Scarp

Photo 4c. Scarp east of P;ru Creek (also shown in photo 3b).

(Original photos in pocket)

S N

Photo 5a. (View of 4a) can be used with 5b for stereoscopic viewing.

S N

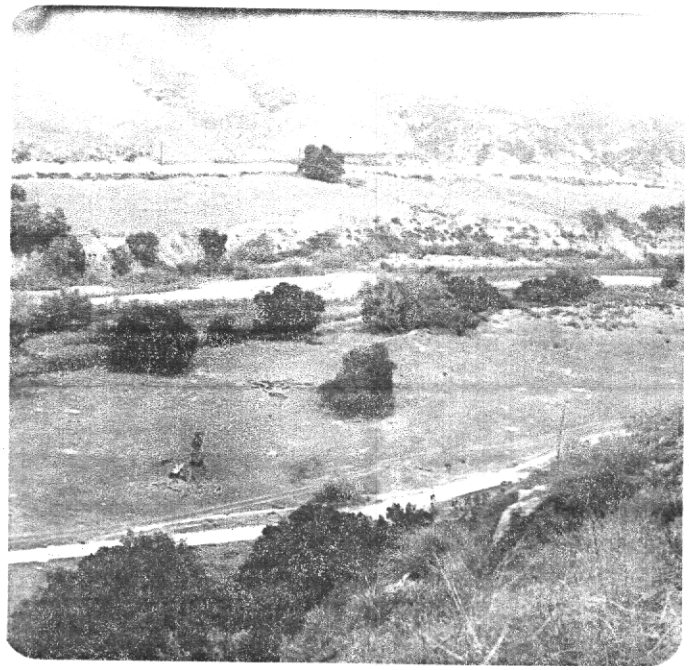


Photo 6a. (View of 4b) can be used with 6b for stereoscopic viewing.

Photo 7. Ground level view to northeast of scarp shown in photos 4a, 5a, and 5b.

S West. East

approx-
mate trace
of fault

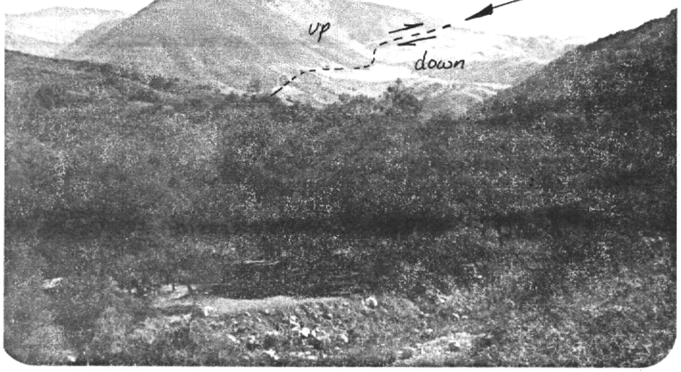


Photo 8. Santa Paula Peak from Camp Bartlett, looking east at the San Cayetano fault. Approximate trace of fault shown. This ridge-front was described by Putnam (1942, p. 705) as a 2000 foot high "composite fault-line scarp."

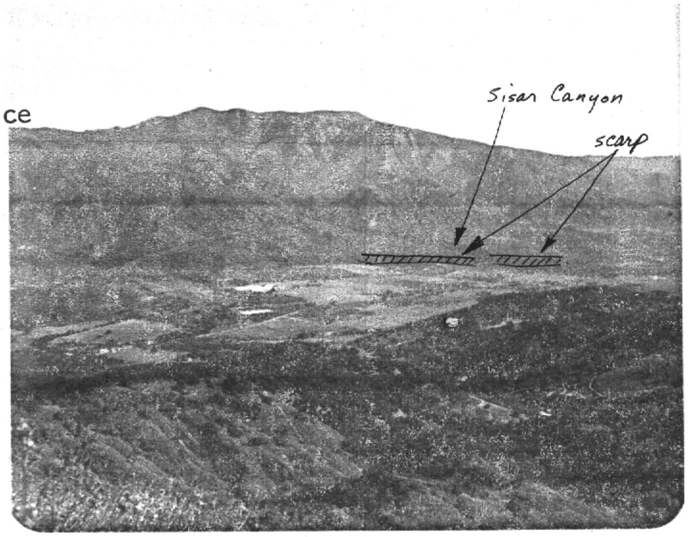
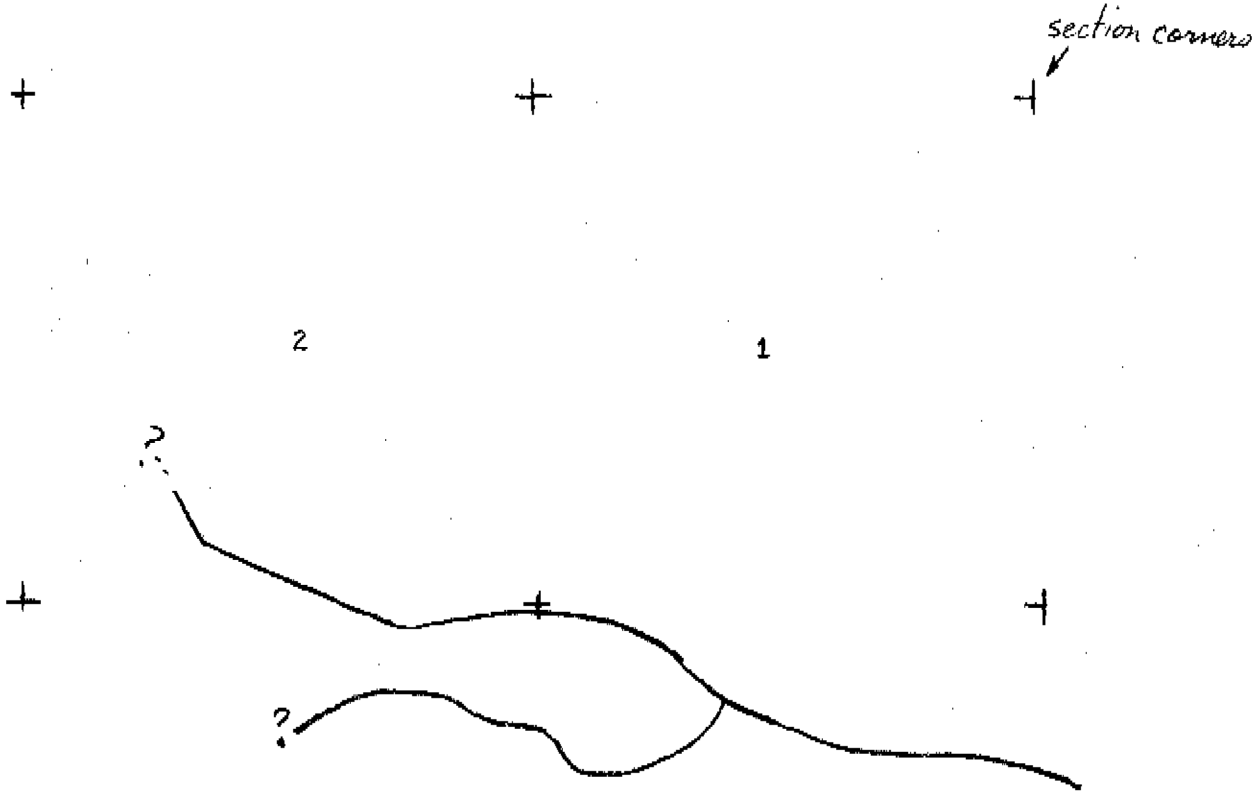
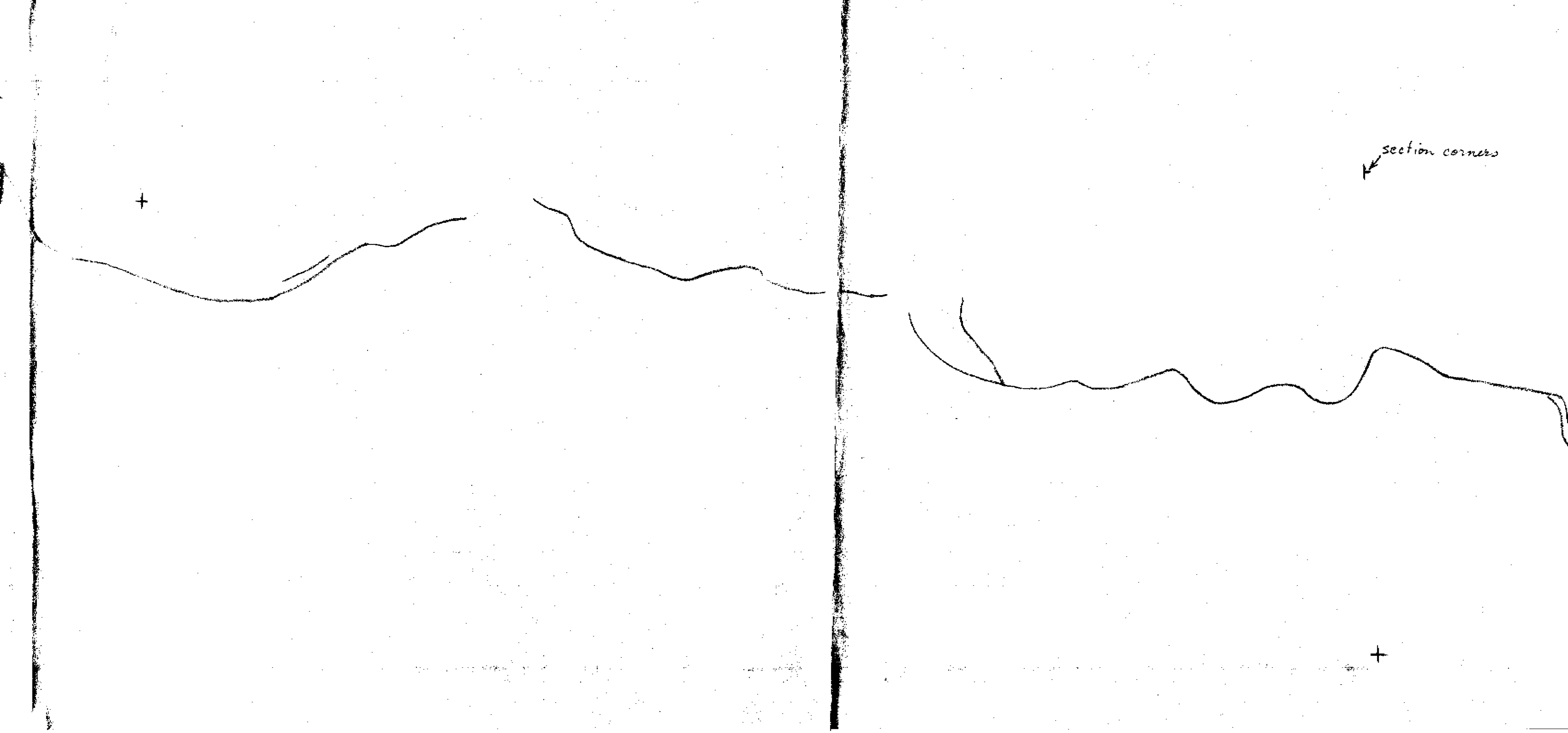


Photo 9. Upper Ojai Valley, showing the San Cayetano fault scarp at Sisar Canyon. Scarp is in late Pleistocene(?) fanglomerate.

FER 19, Plate 1 overlay showing best defined traces of the San Cayetano and related faults.

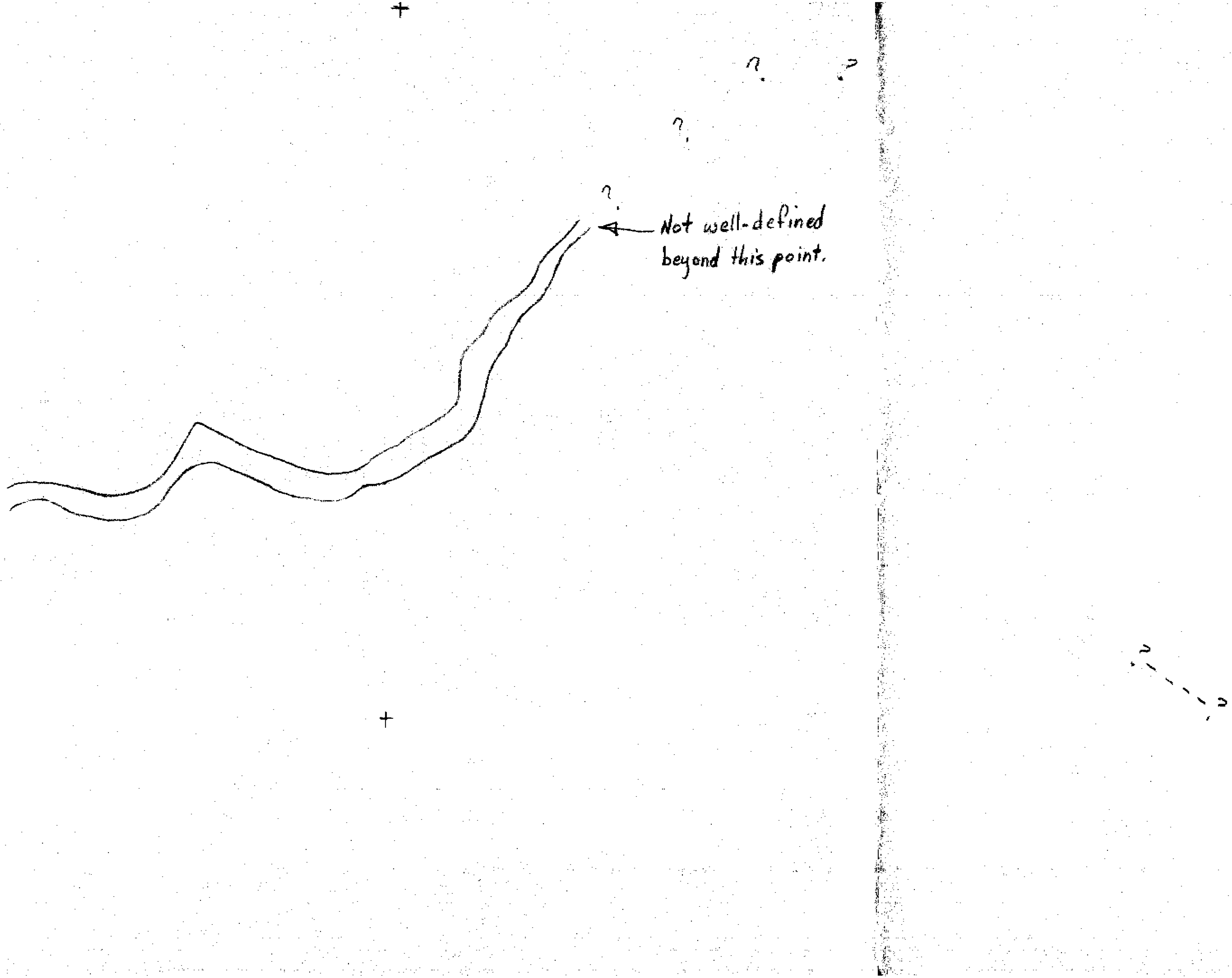


FER 19. Plate 2 overlay
showing best defined traces
of the San Cayetano fault zone.



showing best d
of the San Cayetan

FER 19 PL 3 OVERLAY
SHOWING BEST DEFINED TRAC
OF THE SAN CAYETANO FAUL



Section corners